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# Active sonar and the marine environment

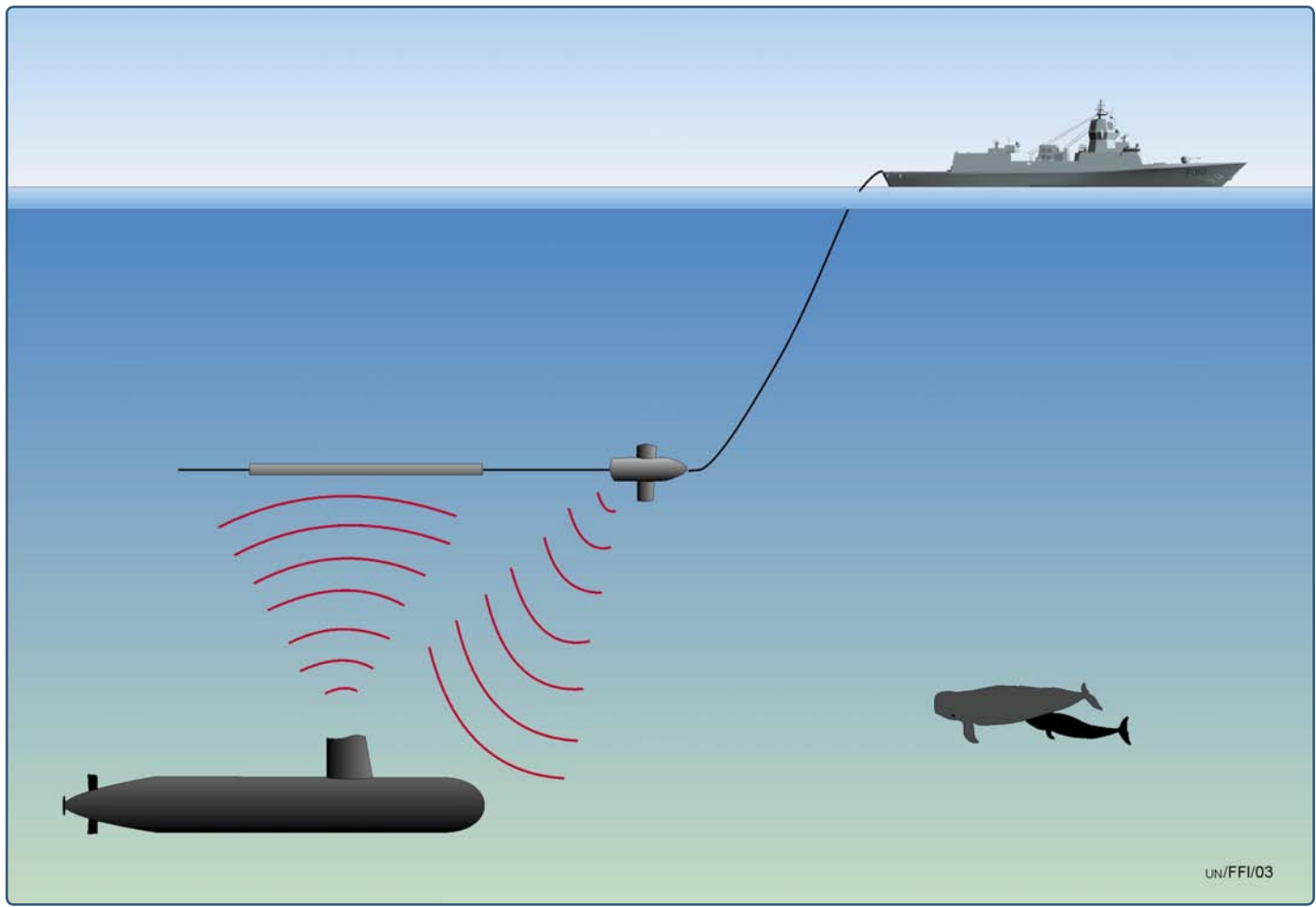
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## Abstract

A study of the effects of active sonar transmissions on fish and marine mammals in Norwegian waters has been launched following ordering of new frigates by the Royal Norwegian Navy (RNoN). The objective of the study is to produce a set of recommended rules for naval sonar operations in Norwegian waters based on scientific grounds. The project includes studies of physiological and behavioral effects of sonar signals on fish and marine mammals, as well as development of a decision aid system to assure responsible operation of naval sonars within Norwegian waters.

## Introduction

The Royal Norwegian Navy (RNoN) is currently building new frigates. The objective of this project is to enable them to operate the sonar-systems of these vessels in an environmentally safe way, without unnecessary operational restrictions.



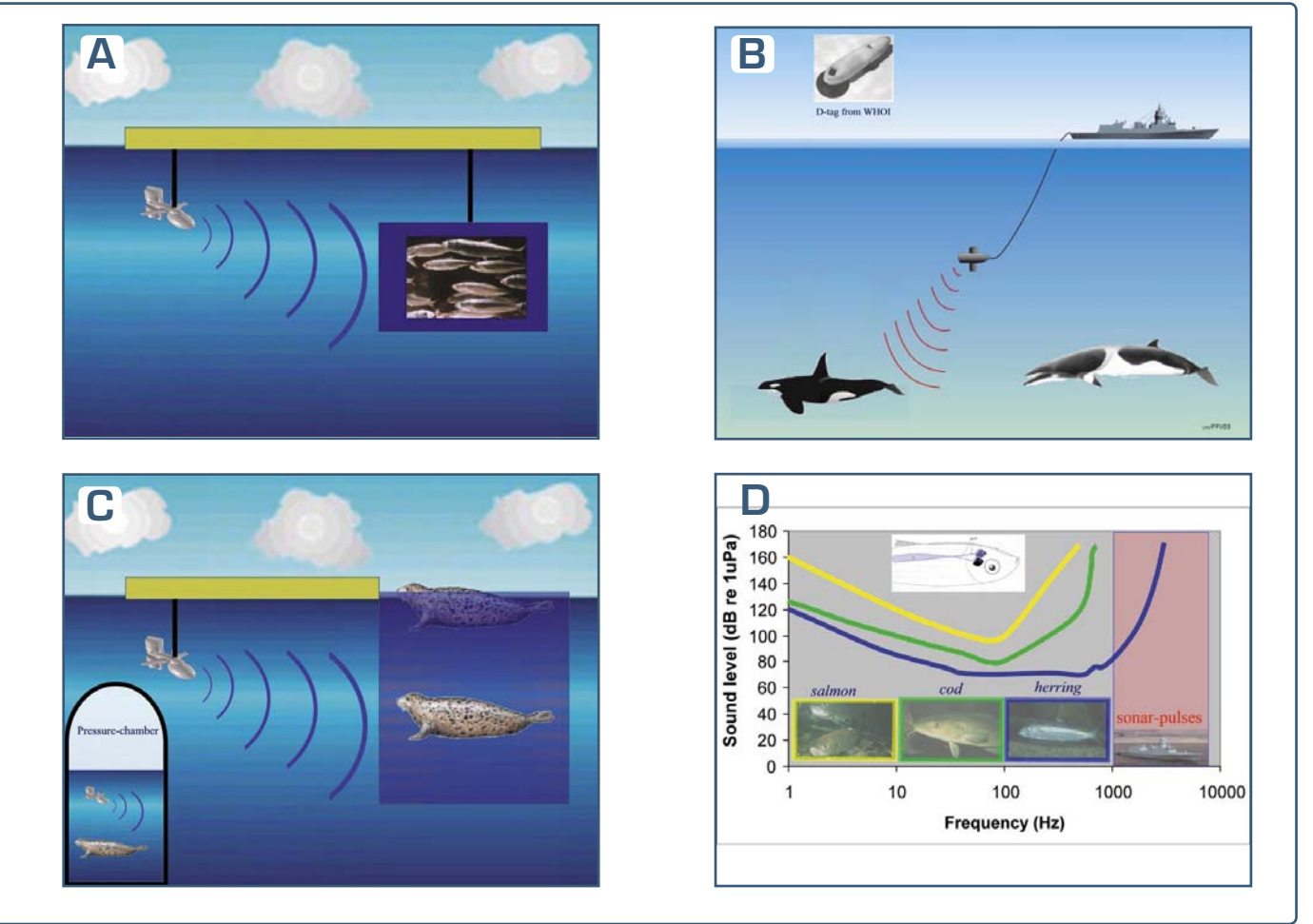
**Fig. 1.** The new frigates will be equipped with sonars operating at lower frequency and over wider frequency bands than previously used in the Navy. This include a towed low frequency sonar (1-2 kHz) in addition to a hullmounted sonar (5-8 kHz) and a helicopter operated dipping sonar (3-5 kHz).

## National group of experts

The project is led by FFI, but we collaborate closely with several national and international partners. A national group of experts on acoustic influence of marine animals, with participants from relevant Norwegian universities and research institutes has been established. This group has, based on existing knowledge and knowledge gaps, recommended four particularly important studies to look at the influence of sonar signals on fish and marine mammals. They will also give advise on operational constraints necessary to assure responsible operation of naval sonars in Norwegian waters.

## Effect studies

The following studies of physiological and behavioral effects of sonar signals on fish and marine mammals have been or will be launched:



**Fig. 2A.** Exposure experiments on fish fry and larvae in collaboration with the Norwegian College of Fisheries Science. Juvenile fish are not able to escape unpleasant influences and in addition the resonance frequency of the swimbladder is expected to be within the frequency range of military sonars. They might therefore be affected by them.

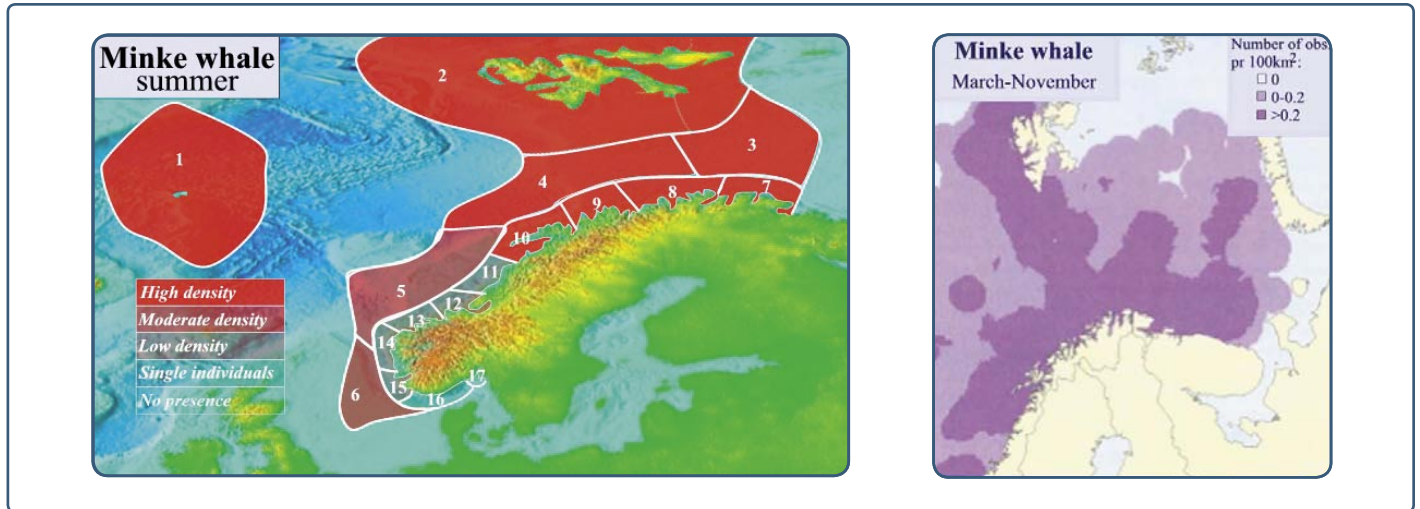
**Fig.2B.** Controlled exposure experiments on minke whales and killer whales in collaboration with Woods Hole Oceanographic Institution (USA), TNO (Netherlands), Institute of Marine Research (Norway) and NATO Underwater Research Center.

**Fig.2C.** Laboratory studies of behavioral and physiological effects of sonar signals on seals, including studies of acoustically induced decompression sickness in seals diving in pressure chamber, in collaboration with University of Tromsø (Norway), Norwegian University of Science and Technology and Rikshospitalet University Hospital (Norway).

**Fig. 2D.** Behavioral studies on adult herring. Due to their specialized swimbladder structure, Clupeid fishes, like herring, have a broader frequency range of hearing than most other species of fish. Since they can hear the sonar signals they can potentially also change behavior in response to them.

## Decision aid – SONATE

In collaboration with the Institute of Marine Research (IMR) and the national group of experts, FFI will develop a decision aid system called SONATE. Based on stored information on acoustic vulnerability and distribution of fish and marine mammals SONATE will generate operational recommendations in accordance with approved national regulations. Officers responsible for planning military exercises and sonar operators on board navy ships will have access to this tool.



**Fig. 3.** Norwegian waters are divided into zones and the years into seasons. This example shows the suggested zones and the expected distribution of minke whales during the summer months.

**Fig. 4.** Where available more detailed distribution maps will also be accessible. Maps like this will be made available from the IMR for some species and time periods.

**Table 1:** Output from SONATE: The operator will choose a zone and a time period for the sonar operation, as well as the sonar systems they want to deploy. When on site, the operator can also add species observed in the area. SONATE will present a list of species and age groups with relevance to the chosen operation, and based on known behavioral and physiological effects it will generate a description of recommended operational constraints to avoid damage to the marine environment during the operation.

Input: Zone 10, summer; Captas, Flash Observations: killer whales			
Species:	Behavioural Effects	Physiological Effects	Operational Recommendations
Cod fry	Non	Not <200dB >200dB no effect on population	No restrictions*
Killer whales	To be investigated	No known	To be decided*
Minke whales	To be investigated	No known	To be decided*

\* Based on known and expected physiological and behavioral effects, recommended operational restrictions will be decided by the National group of experts in collaboration with the Navy, upon completion of the effect studies.